Citation:

Krieger JW, Sitren HS, Daniels MJ, Langkamp-Henken B. Effects of variation in protein and carbohydrate intake on body mass and composition during energy restriction: a meta-regression. *Am J Clin Nutr*. 2006; 83(2):260-274.

PubMed ID: 16469983

Study Design:

Meta-analysis

Class:

M - Click here for explanation of classification scheme.

Research Design and Implementation Rating:

POSITIVE: See Research Design and Implementation Criteria Checklist below.

Research Purpose:

To evaluate and determine if variations in protein and carbohydrate intake affect body mass and body composition measurements during energy restriction.

Inclusion Criteria:

- Studies were included based on the following requirements: stated a dietary intervention, subjects were ≥ 19 years of age, that pre and post dietary measurements were obtained for body composition and body mass were the initial criteria for eligibility.
- Also there needed to be sufficient data to determine energy intake, baseline body mass, macronutrient composition and mean change for the outcome measures.
- In addition the studies were selected if they met a minimum level of dietary control. If dietary intake was self reported a biological marker measurement such as urinary or serum ketones, urinary nitrogen excretion, blood urea nitrogen, or plasma fatty acids was required as an objective measure for compliance or if no biological marker, the investigators had provide ≥ 60% of the subjects' energy intake.

Note: all studies were conducted in accordance with the ethical guidelines.

Exclusion Criteria:

Studies in which the authors reported that the participants were not in full compliance with the dietary intervention were also excluded.

- Inadequate dietary control
- Insufficient reported data for abstraction
- Use of drug or supplement that affected weight loss
- No energy deficit or weight loss
- Postpartum females
- Energy intake 4200 kJ/d (1000 kcal/d)
- Duration < 4 wk
- Hypokinesia

Description of Study Protocol:

Recruitment

- A systematic search was conducted to select studies for this meta-analysis was performed in PubMed, the Cochrane Central Register of Controlled Trials in Cumulative Index of the Nursing and Allied Health Literature, and SportDiscus, between January 1, 1950 and September 18, 2005.
- Specific search words were used and articles were also selected from the bibliography of the articles initially extracted.
- Studies for the analysis were selected and only English language studies that involved a dietary intervention 1000 kcal/d (4200kj/d) and 4 weeks or greater duration (mean duration was used).
- The studies involved adults > or equal to 19 years or older.
- The studies were used if they reported a self-reported method of intake plus a biological marker for a macronutrient to establish dietary adherence.

Design: Meta-analysis
Blinding used (if applicable): not applicable
Intervention (if applicable):

- Data extracted included: study design, *n*, age, sex, baseline body mass (kg), quality of dietary control (moderate or high), duration of treatment (wk), exercise intervention (yes or no), method to measure body composition (field or laboratory), protein intake (percentage of energy, total g, and g/kg body mass), carbohydrate intake (percentage of energy and total g), fat intake (percentage of energy and total g), total energy intake (kJ), body mass change (kg), fat-free mass change (kg), percentage change in body fat (BF), and percentage change in fat mass (FM).
- All results were tabulated onto a spreadsheet with the use of Microsoft Excel. If the data was available the data was calculated from the original article. Quartiles were used for carbohydrate intake separated into low (1st quartile) and high (quartiles 2–4) intakes and protein intake separated into low (less than or equal to the median) and high (more than the median) intakes.
- The measurement of body composition was placed in either the category laboratory measure (i.e. dual-energy X-ray absorptiometry, air densitometry, or hydrodensitometry) or a field measure (i.e., skinfold thicknesses, bioelectric impedance analysis, or total-body electrical conductivity.
- Reliability of the abstraction process was assessed by an independent investigator. 10 randomly selected studies recoded and divided into the same variables. A mean agreement of 0.96 was achieved thus indicating the abstraction process was reliable.

Statistical Analysis

- Variance within each intervention group was calculated as the squared SEM of the difference between pre- and postdate outcomes with each study. If available SEM of the difference was calculated by using the *P* value or CI. Meta-analyses were performed using hierarchical linear mixed models.
- Histograms of residuals were examined to identify major departures from normality; no significant departures
- from normality were found. Publication bias was assessed via funnel plot regression method described by Macaskill et al
- A sensitivity analysis was conducted to identify the presence of significantly influential studies that could lead to biased analysis for each model of the meta-analysis. Studies were considered influential if not used in the analysis caused a SE > 1. Results for the of the meta-analysis were considered significant if P > 0.05

Data Collection Summary:

Timing of Measurements

A systematic search was conducted to select studies for this meta-analysis was performed in PubMed, the Cochrane Central Register of Controlled Trials in Cumulative Index of the Nursing and Allied Health Literature, and SportDiscus, between January 1, 1950 and September 18, 2005. Specific search words were used and articles were also selected from the bibliography of the articles initially extracted.

Dependent Variables

- Body mass and body composition

Independent Variables

- Carbohydrate and protein intake during energy restriction

Control Variables

Description of Actual Data Sample:

Initial N: Total of 87 studies comprising 165 groups met the inclusion criteria for the analysis. Total relevant articles (excluding duplicates) 771, total articles included (excluding duplicates) 87, and total articles excluded from analysis 694. Excluded due to exclusion criteria:

- Insufficient reported data for abstraction (101)
- Use of drug or supplement that affected weight loss (13)
- No energy deficit or weight loss (38)
- Postpartum females (1)
- Energy intake 4200 kJ/d (1000 kcal/d) (166)
- Duration 4 weeks (49)

Attrition (final N): 87 studies

Age: not reported

Ethnicity: not reported

Other relevant demographics

Anthropometrics

Location: international studies

Summary of Results:

Key Findings

- After control for energy intake, diets consisting of <35 - 41.4% energy from carbohydrate were associated with a 1.74 kg greater loss of body mass, a 0.69 kg greater loss of fat-free mass, a 1.29% greater loss in percentage body fat, and a 2.05 kg greater loss of fat mass than were diets with a higher percentage of energy from carbohydrate
- In studies that were conducted for >12 weeks, these differences increased to 6.56 kg, 1.74 kg, 3.55% and 5.57 kg, respectively.
- Protein intakes of >1.05 g/kg were associated with 0.60 kg additional fat-free mass retention compared with diets with protein intakes <1.05 g/kg
- In studies conducted for >12 weeks, this difference increased to 1.21 kg
- No significant effects of protein intake on loss of either body mass or fat mass were observed

Fat-free mass change

- The amount of FFM retained tended to increase with each successive quartile of protein intake, with a significant difference existing between the upper 2 quartiles (>1.05 g/kg) and the first quartile.
- Protein intake was found to be a significant predictor of FFM retention. Daily protein intake of 1.05g/kg (mean intake in the high protein studies was 1.27g/kg) was strongly associated with a greater FFM retention than those with protein intake within the RDA (mean intake 0.74g/kg). This relationship was stronger with greater

duration studies especially > 3 months.

Diets (no publication bias found)

- When the carbohydrate intake was in the lowest quartile (≤ to 35% energy) were associated with a 1.6 –1.7 kg greater body-mass loss than were diets with carbohydrate intake in the highest 3 quartiles.> 35% energy.
- In studies conducted for less than or equal to 12 wk the estimated decrease in weight was 1.25 kg (CI: 0.45, 2.04 kg). In studies conducted for > 12 wk, low-carbohydrate diets were associated with a 6.56 kg greater body-mass loss than were high-carbohydrate diets (CI: 3.78, 9.34 kg). .No significant effects of protein were observed.

Fat mass changes

- Protein intake in the third quartile (>1.06 and ≤1.18 g/kg) was associated with a greater loss of FM (1.68 kg; CI: 0.01, 3.35 kg) than was the first quartile of protein intake (≤ 0.73 g/kg). However at the lowest percentile and highest percentile no significant of protein intake and FM.

Percent body fat

- Diets with a carbohydrate intake ≤ 41.4% energy were associated with a 1.32–1.48% greater decrease in percentage BF than were diets with carbohydrate in the highest 3 quartiles (1.29%; CI: 0.46%, 2.12%).
- Studies conducted for ≤ 12 wk, had the greater loss in percentage BF in the lowest carbohydrate intake quartile tended toward significance (1.00%; CI: -0.06%, 2.06%; *P* = 0.06).
- The mean change was -3.00% (CI: -3.53%, -2.46%). Protein intake in the third quartile (>1.06 g/kg and ≤ 1.20 g/kg) was associated with a greater loss of percentage BF (1.32%; CI:0.11%, 2.53%) than was the first quartile (< or =0.73 g/kg). Protein intake classified as high (>1.06 g/kg) there was a trend toward a greater BF percentage loss as compared to low (≤1.06 g/kg), (*P*= 0.09) toward a 0.64% (CI:-0.09%, 1.38%).

Other Findings

- Low carbohydrate diets (35–41.4% energy) increased the loss of body mass, BF, and percentage BF as compared to higher carbohydrate diets.
- There was no significant effects seen on loss in body mass or fat mass as it relates to protein intake.

Author Conclusion:

Low-carbohydrate, high-protein diets positively affects body mass and composition (FFM, FM, and percentage BF). This relationship was independent of energy intake. This data supports the proposed metabolic effects of these diets as compared to traditional diets. Consuming > 1.05 g/kg protein was more optimal for FFM retention than consuming the RDA therefore the RDA for protein may not be sufficient for maintaining FFM retention.

Reviewer Comments:

The strength of this meta-analysis was the care the authors took for data extraction and analysis completed for replication validity.

Research Design and Implementation Criteria Checklist: Review Articles

Relevance Questions

1.	Will the answer if true, have a direct bearing on the health of patients?	Yes
2.	Is the outcome or topic something that patients/clients/population groups would care about?	Yes
3.	Is the problem addressed in the review one that is relevant to nutrition or dietetics practice?	Yes

4.	Will the information, if true, require a change in practice?	Yes

Validity Questions		
1.	Was the question for the review clearly focused and appropriate?	Yes
2.	Was the search strategy used to locate relevant studies comprehensive? Were the databases searched and the search termsused described?	Yes
3.	Were explicit methods used to select studies to include in the review? Were inclusion/exclusion criteria specified and appropriate? Were selection methods unbiased?	Yes
4.	Was there an appraisal of the quality and validity of studies included in the review? Were appraisal methods specified, appropriate, and reproducible?	Yes
5.	Were specific treatments/interventions/exposures described? Were treatments similar enough to be combined?	Yes
6.	Was the outcome of interest clearly indicated? Were other potential harms and benefits considered?	Yes
7.	Were processes for data abstraction, synthesis, and analysis described? Were they applied consistently across studies and groups? Was there appropriate use of qualitative and/or quantitative synthesis? Was variation in findings among studies analyzed? Were heterogeneity issued considered? If data from studies were aggregated for meta-analysis, was the procedure described?	Yes
8.	Are the results clearly presented in narrative and/or quantitative terms? If summary statistics are used, are levels of significance and/or confidence intervals included?	Yes
9.	Are conclusions supported by results with biases and limitations taken into consideration? Are limitations of the review identified and discussed?	Yes
10.	Was bias due to the review's funding or sponsorship unlikely?	Yes